Air Quality in Several Okanagan Communities, Princeton, and Grand Forks 1973–1989

BC Environment

QC
ES
D:A4532
1991
c.3

AIR QUALITY IN SEVERAL OKANAGAN COMMUNITIES, PRINCETON, AND GRAND FORKS 1973 - 1989

Howard Richardson*

E.V. Jensen

and

J.E. Bryan

B.C. Environment

Penticton

July 1991

*Okanagan College, Penticton, B.C.

92-01390/

Canadian Cataloguing in Publication Data
Richardson, Howard, 1944-
Air quality in several Okanagan communities, Princeton and Grand Forks, 1973-1989

ISBN 0-7726-1399-0

1. Air quality - British Columbia - Okanagan Valley. 2. Air quality - British Columbia - Princeton. 3. Air quality - British Columbia - Grand Forks. 4. Wood waste - Burning - Environmental aspects - British Columbia - Okanagan Valley. 5. Wood waste - Burning - Environmental aspects - British Columbia - Princeton. 6. Wood waste - Burning - Environmental aspects - British Columbia - Grand Forks. 7. Ozone. I. Jensen E.V. (Ernest Victor) II. Bryan, J.E. III. British Columbia. Environment. IV. Title.

TD883.7.C32B753 1991 363.73'922'097115 C91-092263-2

EXECUTIVE SUMMARY

This report describes air quality in the Okanagan Sub-Region of British Columbia Environment. The report presents information for Vernon, Lumby, Kelowna, Penticton, Okanagan Falls, Princeton and Grand Forks for the years 1973-1989. Some information in Vernon and Lumby is included for 1990 and early 1991.

The report presents air quality data relative to existing quality objectives (standards). The report also compares trends in quality through time and air quality in different locations.

The purpose of much of this air quality sampling is to evaluate the effects of woodwaste burners on air quality. Consequently, many of the sampling devices are located close to woodwaste burners and interpretations are made to show the effect of woodwaste burners on air quality.

The total amount of suspended particulate material in the air is high in Lumby and Vernon when compared with other towns in British Columbia. In Lumby there was an improvement in the suspended particulate level between the 1970's and 1980's. Even so, the level remained high through 1988. The dustfall from air at Lumby did not decrease between 1970's and 1980. At a number of locations sampled near woodwaste burners the amount of dustfall exceeds the recommended levels much of the time. In some instances, the high dustfall resulted from dust blowing around unpaved logyard areas rather than from woodwaste itself.

The causes of the high suspended particulate in Vernon cannot be determined from information in this report. Additional analysis or study will be required in order to determine with certainty where the suspended particulates in Vernon originate.

Ozone in Kelowna is within the objectives for an acceptable annual average. However, in spring and early summer some daily measurements exceed the objectives for ozone.

TECHNICAL ABSTRACT

This report summarizes information on total suspended particulate levels and dustfall in the Okanagan Sub-Region, which includes the Okanagan Valley, Lumby, Princeton, and Grand Forks, from 1973 to 1989. For comparison, a few data are included for 1990 and early 1991.

Total suspended particulate levels in Lumby and Vernon were high, compared with a number of other sites in British Columbia. On some days, the readings exceeded Provincial objectives. TSP (total suspended particulate) levels in Kelowna, Westbank, and Penticton, however, were well within Provincial objectives.

Compared to the 1970's, current TSP levels have decreased in Lumby and Kelowna, were consistently low in Penticton, and were not measured during the 1970's in either Vernon or Westbank. The improvement in Kelowna could have been due to moving the sampler to a new location.

Each year a varying number of observations made in Lumby and Vernon exceeded the TSP level deemed acceptable by the Federal Government. The number of days exceeding the acceptable level has decreased since the 1970's. The source of the TSP in Vernon could not be established unequivocally.

Fifty-four percent of dustfall measurements, made at 25 sites in the area, exceeded the Provincial Government's A objective, and 39% exceeded the less stringent B objective. There is no indication that dustfall had decreased at any of the sites, up to 1988. Inefficiently-operated woodwaste burners are usually assumed to contribute significantly to combustible dustfall but there was also a large non-combustible component to dustfall around several burners.

The mean daily ozone level at Kelowna for years 1985 - 1989 was approximately 39 ug/m^3. Ozone levels are highest during the months of April, May, June and July. A maximum mean daily ozone level of 112 ug/m^3 was recorded in May 1987. During the same month, 16% of the one hour concentrations were greater than 100 ug/m^3. No trend in annual average ozone is evident at Kelowna for the period of measurement.

PREFACE

The goal of the Air Management Program of British Columbia is to maintain or improve air quality in British Columbia. This report give an overview of air quality in the whole Okanagan Sub-Region. It shows examples where air quality has improved as a result of actions taken by B.C. Environment and lumber mills. It also shows areas where air quality is still below measures of acceptability. This report will serve as a useful benchmark in establishing that the Air Management Program can achieve its goal. It will facilitate improvements in air quality where needed. It will be useful for developing air Management Plans.

ACKNOWLEDGEMENTS

A number of B.C. Environment staff reviewed and offered comment on this report: P. Jarman, P. Reid, R. Williams, B. Manna, R. Davis, R. Nickel and D. Hall. A summary of the report was presented verbally to her Worship Mayor Clark of Vernon and interested members of Vernon council and staff in 1989. Their ideas and comments were useful. Assistance in typing was given by Bev Russell and Pat Albinet.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY.....i

TECHNICAL ABSTRACT..... ii

TABLE OF CONTENTS iii

PREFACE / ACKNOWLEDGEMENTS iv

LIST OF FIGURES v

LIST OF TABLES v

1. INTRODUCTION 1

1.1 Data Collection Methods 1
1.2 Data Interpretation 2
1.2.1 Dustfall 2
1.2.2 Suspended particulates 2
1.2.3 Weather effects 3
1.3 Data Sources 3

2. TOTAL SUSPENDED PARTICULATES 5

2.1 Long Term Geometric Mean TSP 5
2.2 Annual Geometric Mean TSP 6
2.2.1 Historical Trends 7
2.3 Daily TSP 9
2.3.1 Historical Trends 11
2.4 Comments 11

3. DUSTFALL 13

3.1 Total Dustfall 13
3.1.1 Historical Trends 15
3.1.2 Comments 17
3.2 Combustible Dustfall 18
3.2.1 Comments 21

4. OZONE 21

5. REFERENCES 23

6. APPENDIX 24

LIST OF FIGURES

Page

1. Geometric mean of Total Suspended Particulates for the Okanagan and eight other sites in British Columbia 5
2. Monthly geometric mean of Total Suspended Particulates for Lumby, Vernon, and Kelowna 7
3. Annual geometric mean of Total Suspended Particulates in the Okanagan from 1972 to 1989 8
4. Percentage of 24-hour Suspended Particulate measurements made in (a) Lumby, (b) Vernon, and (c) Kelowna between 1973 and 1989, that exceeded federally-acceptable, Provincial A, and Provincial B objectives (numbers above bars show the number of measurements made in that year) 10
5. Total particulate and combustible dustfall at Lumby Weyerhaeuser during 1985 and 1986 18
6. Monthly mean ozone levels at Kelowna, Okanagan College for Years 1985 to 1988..... 22
7. Appendix Figure 1, TSP in Vernon 1985 to May 1991..... 25
8. Appendix Figure 2, Dustfall in Vernon 1985 to May 1991..... 25

LIST OF TABLES

Page

1. Location and type of sampling devices 4
2. Annual geometric means of Total Suspended Particulates..... 6
3. Correlation coefficients between TSP levels 12
4. Geometric means of total particulate dustfall recorded in 1973-1984 and 1985-1989 14
5. The number of total particulate dustfall records exceeding Provincial air quality objectives 15
6. Percentage of records from 1973-1984 and 1985-1989 exceeding Provincial A air quality objective 16
7. Percentage of records from 1973-1984 and 1985-1989 exceeding Provincial B air quality objective 17
8. Geometric means of combustible dustfall from 1973-1984 and 1985-1989 19
9. Combustible dustfall as a percentage of total dustfall and coefficients of correlation between combustible and non-combustible dustfall 20
10. The percentage of 1-hour ozone records per month greater than the Provincial A air quality objective of 100 ug/m^3 at Okanagan College, Kelowna from 1985 - 1988..... 22

1. INTRODUCTION

The aim of this report is to summarize and evaluate, B.C. Environment information on air quality in the Okanagan Sub-Region, including the Okanagan communities as well as centres, Lumby, Princeton, and Grand Forks. It is hoped that the information presented here will be of use to a variety of interested groups. Consequently, the comments on statistical and data collection methods may seem redundant to some, but are included for the benefit of potential readers with expertise in these fields.

The report summarizes the data from 25 dustfall canisters six high volume samplers, and one ozone analyzer in the Okanagan Sub-Region. The data are examined with respect to Federal and Provincial air quality objectives, and where possible, compared with previous data.

Both Provincial and Federal Governments have set air quality objectives in terms of TSP (total suspended particulates) and dustfall rate. The TSP objectives are target levels for the mass of suspended particles in any cubic metre of air, either as the geometric mean of a year's data or for single 24-hour measurements. It should be clearly understood by readers of this report that, due to sparsity of data from some sites, and changes in both location and type of sampler, inferences regarding the source of materials collected in the samplers, are often disputable and sometimes even temporal changes in the rates of deposition. The geometric mean is calculated from values converted to their logarithmic form. This is done because the data are not distributed normally (i.e. in the form of a "bell curve") and the average (arithmetic mean) calculated directly from these values can be greatly elevated by a few extreme values. The geometric mean is not influenced as strongly by extreme values.

Dustfall objectives are recommended limits to the mass of particles falling on a unit area in a day. This is normally expressed as $mg/dm^2/d$.

1.1 DATA COLLECTION METHODS

High volume samplers measure the mass of suspended particles in a fixed volume of air that is drawn through a filter. They normally operate for 24 hours every sixth day. The various filtering devices (such as the high volume sampler) are characterized by the size-range of particles that they collect.

This size-range is determined by the mesh size of the filter through which the air is drawn and by any pre-filtration treatments of the air. Commonly, the intake duct or some other mechanism, deflects the indrawn air so that large particles are centrifugally removed from the air-stream before it passes through the filter. Since this is a stochastic process, the particle size at which 50% of the particles are eliminated from the air flow, and 50% stay in it, is taken as the effective, upper size limit (50% cut-off) for the sampling procedure.

The 50% cut-off for the high volume samplers used in this, and many other monitoring programs, is 30 um. More recent studies (Crozier and Manna 1989, Reid 1989) have used samplers with a 50% cut-off of 10 um (referred to as the PM10), and of 2.5 um. There was a strong correlation between TSP levels and PM10.

Dustfall canisters are open vessels, containing a collecting solvent, that collect all particles dropping into them. Settlement rates obviously depend on particle size and shape, but canisters are selective for particles 20 to 40 um in diameter and larger because of their rapid settlement rate. They operate continuously, but each month canisters are sealed, sent for analysis, and replaced by new ones. Dustfall analysis consists of measuring the total mass of the collected particles that are soluble or insoluble in the collecting solvent, and the soluble or insoluble ash (i.e. the portion remaining after the organic component is burned off). The total dustfall and combustible dustfall are calculated from these measurements.

In the past two to three years, B.C. Environment has undertaken testing programs in the Okanagan for several other potential airborne contaminants, such as ozone and poly-cyclic aromatic hydrocarbons. The sampling techniques for these are generally more complex. Ozone sampling is discussed in more detail in Section 4.0.

1.2 DATA INTERPRETATION

In recent years there has been a growing awareness that airborne particles vary greatly in physical and chemical nature, in their impact on the environment, and on human health. Detailed studies of air quality now collect samples that show the relative proportions of the different size fractions of airborne particles. It is hoped the additional information will give a better indication of health hazards, and the probable sources of pollution.

1.2.1 Dustfall

Dustfall canisters are selective for large particles that would not normally enter the human respiratory tract and are considered to present more of an aesthetic and nuisance problem than a serious health hazard to humans. It has become obvious that TSP and dustfall may not be the best indicators of air quality. However, they are the only measures for which there are any data with temporal or geographic depth.

Combustible dustfall is presumed to be the result of inefficient operation of woodwaste burners. Incomplete combustion of fuel will lead to the emission of particles that are still combustible, and may be the result of wet or dirty fuel, sub-optimal fueling rates, poor damper operation, inappropriate draughting through poorly-maintained burner walls, or a variety of other factors. Fugitive sawdust from other sections of a mill will also contribute to combustible dustfall. The permitted emissions from a sawmill are normally expressed in terms of combustible

dustfall. Non-combustible dust probably originates either from the activity of heavy vehicles in unpaved log-sort yards, or from the thermal venting of fly-ash from burners operating at very high temperatures.

1.2.2 Suspended Particulates

PM10 has been adopted as a significant measure of air quality since 10 um has been shown as the upper size limit for particles that will enter the lower respiratory tract during normal respiration. Any compounds associated with, or constituting, such particles will obviously come into intimate contact with the blood supply and can pose a major hazard to health. The residence time in the lungs of smaller (sub-micron) particles is also longer than for larger particles (Anderson 1967). Neither the Federal nor British Columbia Government has set PM10 air quality objectives, but the U.S. 24 nour acceptable limit is 150 ug/m^3 and that for the State of California is 50 ug/m^3.

Recent air quality monitoring programs have also incorporated measurements of the poly-cyclic aromatic hydrocarbon (PAH) loading. These compounds are the product of incomplete combustion of such organic fuels such as cigarettes, gasoline, and wood. They include a number of highly carcinogenic compounds e.g bezo-[a]-pyrene (Katz 1967, Anderson 1967). The lack of long-term data, for the Okanagan, on PAH levels or the proportion of suspended particulates (TSP) that is respirable, seriously limits the inferences that can be made from the data. It is, however, a problem common to most current, long-term air quality studies.

1.2.3 Weather Effects

There are several demonstrable, seasonal trends in air quality (Richardson, Adams and Bryan 1991) although the causal relationships are unclear. There was no relationship between mean monthly precipitation and dustfall in the Lumby-Lavington area, though rainfall was expected to have a scrubbing effect, and the dry weather of summer to result in high levels of fugitive non-combustible particles. Combustible dustfall was inversely related to mean monthly temperature, probably because wood waste remains wet or snow-covered during the coldest months. TSP levels were also highest between November and February.

1.3 DATA SOURCES

The site number and name of the sampling stations from which data were used to compile this report are given in Table 1. TSP measurements for the period 1983 to 1989 were gleaned from: SEAM, EQUIS, and the National Air Pollution Surveillance Monthly Summaries. Dustfall data for that period was taken exclusively from SEAM. An historical perspective is provided by comparison with data from EQUIS and Leung and Manna (1986). Leung and Manna (1986) summarize data for 1976 to 1982 from a variable number of both high volume samplers (1 to 3, sites not specified) and dustfall canisters (16 to 34, sites again not given). The EQUIS data covers varying periods and sampling intensities between 1973 and 1983.

TABLE 1

Location and type of sampling device at air quality sampling stations that contributed data for this report.

Number	Site Name	Hi-vol sampler	dustfall canister
e206303*	Lumby Weyerhaeuser W		x
e206301*	Lumby Chas. Bloom School		x
e206302*	Lumby Home Furnishings	x	x
0500134	Lumby Air South		x
0500131	Lumby Hotel	x	x
0500655	Lumby Ruesch Residence		x
0500698	Lavington Air East		x
0500439	Lavington Harber		x
0500827**	Vernon RCMP	x	x
e206304	Kelowna Okanagan College	x	x
0500137	Kelowna Sunripe	x	x
e207439	Westbank Gorman Bros'. N		x
e207438	Westbank 2816 Glen Rosa Rd.		x
e206869	Summerland Forest Products N.		x
e207870	Summerland Forest Products NNW.	x	x
0500156	Penticton STP	x	x
0500153	Penticton Slumberlodge	x	x
0500869	Penticton Carmi School	x	x
0500520	Okanagan Falls Lynn Acres		x
0500825	Okanagan Falls South		x
0500826	Okanagan Falls Control		x
0500738	Princeton Roccomatisi Res.		x
0500783	Princeton #13 Pines Court		x
0250041	Grand Forks Clark		x
0250044	Grand Forks North Parta		x
0500762	Grand Forks Makaoff		x
0500763	Grand Forks Mayflower Hotel		x
0500910	Grand Forks Como Rd.		x

* sites e206301, 2, 3, and 4 were originally numbered 0500700, 701, 702, and 886, respectively

** sampler originally located on the Geniers Building and relocated to RCMP HQ in 1986

2. TOTAL SUSPENDED PARTICULATES (TSP)

2.1 LONG TERM GEOMETRIC MEAN TSP

The geometric means for the total data set for each of the major Okanagan sites are shown in Figure 1, together with data from a selection of sampling stations in other areas of the province. There is one station, chosen solely on the basis of having a complete data set, from each of the Ministry of Environment Regions. Vernon and Lumby have the highest levels of suspended particulates of any of the sites, and these include such wood processing and industrial centres as Williams Lake, Prince George, and Trail. Williams Lake, in particular, is recognized as having a serious air quality problem as a result of sawmill burner activity (Bhattacharya 1988; Reid 1989), while air quality in Cranbrook is thought to be deteriorating due to domestic wood-fueled heaters (Crozier and Manna 1989).

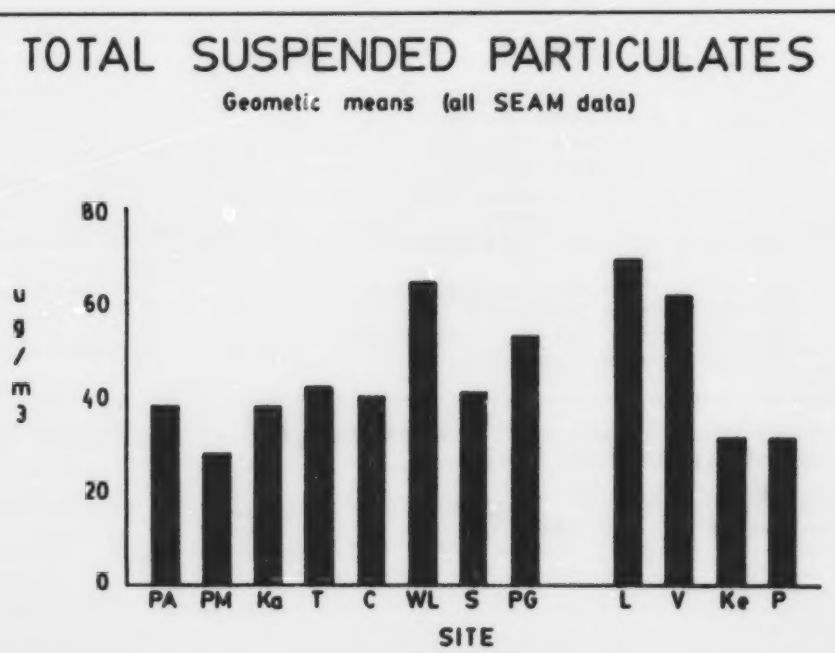


Figure 1. Geometric Mean (ug/m^3) of Total Suspended Particulate measurements for 1985-1988, for Okanagan high volume samplers and for eight other B.C. Sites.)PA Port Alberni, PM) Pitt Meadows, Ka) Kamloops, T) Trail, C) Cranbrook, WL) Williams Lake, S) Smithers, PG) Prince George, L) Lumby, V) Vernon, K) Kelowna, P) Penticton.

2.2 ANNUAL GEOMETRIC MEAN TSP

Both Federal and Provincial air quality objectives (see Appendix A) are expressed in terms of annual geometric mean TSP (Anon 1977, 1979, 1983, Good & Doering 1980). The annual geometric means of TSP data available on SEAM are shown in Table 2.

Care must be taken when interpreting these data. There are seasonal trends in TSP levels (Figure 2), so annual means calculated from incomplete data may over- or under-represent periods of extreme TSP level. For example, data were collected only from January to April in 1985 at the Vernon site. This is a period of high TSP levels and consequently an annual mean calculated from this data is probably artificially high. Therefore, these data from Vernon, along with the 1983 data from all four sites must be considered suspect. There were insufficient data for 1989 to warrant a separate analysis.

TABLE 2

Annual geometric means of Total Suspended Particulates (ug/m^3) measured at the four Okanagan high volume sampling sites (sample size in parenthesis)

Site	1983	1984	1985	1986	1987	1988	1989	1990
Lumby	114.8 (20)	58.3 (44)	62.2 (43)	65.4 (40)	84.6 (48)	73.3 (46)	59.3 (45)	57.8 (53)
Vernon	56.3 (17)	73.1 (44)	132.2 (14)	57.0 (51)	67.4 (59)	49.2 (50)	52.9 (37)	64.4 (61)
Kelowna	30.1 (19)	30.1 (52)	28.1 (57)	38.3 (47)	61.9 (30)	32.7 (19)		
Penticton	34.6 (17)	30.0 (53)	39.9 (51)	26.4 (48)	36.1 (26)	31.4 (44)	32.1 (37)	31.5 (53)
Westbank						30.4 (42)		

The annual geometric mean TSP levels in both Penticton and Kelowna are consistently within the limit of desirability set in both Federal and Provincial objectives. The Westbank Glen Rosa Road sampler gave a geometric mean of 30.4 ug/m^3 (42 samples from July 1988 to October 1988), consistent with the values for Kelowna and Penticton. By contrast the levels in Vernon and Lumby frequently exceeded both desirable and acceptable limits. Only two months data were available for the Summerland sampler.

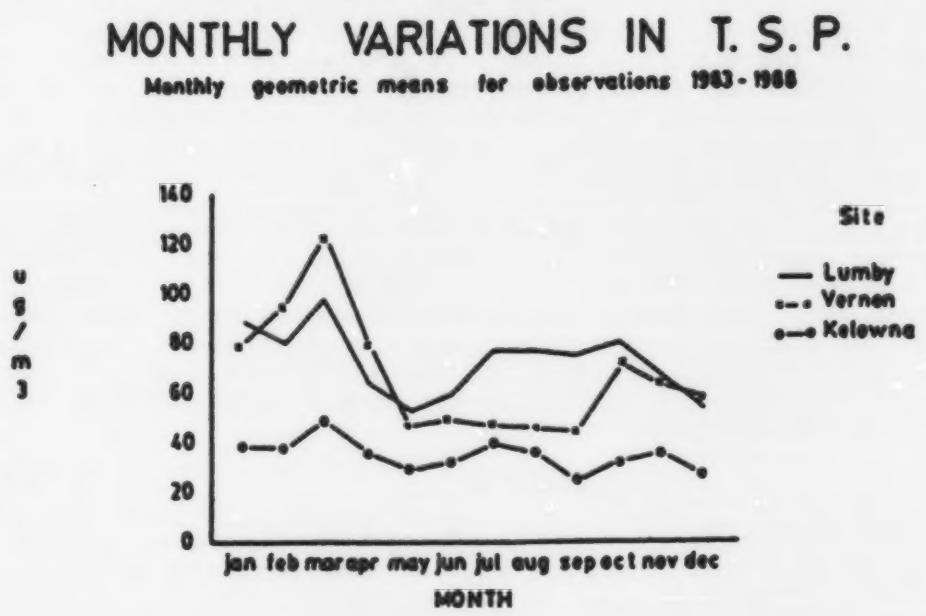


Figure 2. Monthly variations in geometric mean Total Suspended Particulate levels (ug/m^3) for Lumby, Vernon, and Penticton.

2.2.1 Historical Trends

Data for the period 1971 to the creation of the SEAM program are sketchy and incomplete. It was possible to make direct historical comparison for only one of the four current high volume sampling sites. A high volume sampler was operated on top of the Lumby Hotel (site 0500131) from 1971 to 1976. This is only about 50m from the current sampling station.

No high volume sampler was operated in Vernon before 1979, and was only operated consistently as of 1983. This sampler was moved from the Genier's Building 500 metres to the north, to the R.C.M.P. Building, in July of 1986.

Comparison of data from the two Kelowna sites is particularly difficult. From 1971 to 1979 the sampler was located at the Sunripe plant (site 0500137) in the industrial core of the city. It is now located at Okanagan College. This site was originally semi-rural, but has been engulfed gradually by the burgeoning, residential sprawl of Kelowna.

In Penticton prior to 1979 there were two high volume samplers; one at the sewage treatment plant (site 0500156) and the other at Penticton Slumberlodge (site 0500153). The overall geometric means of data from these two sites operated between the early 70's and 1982 are 42ug/m^3 (N=556) and 47ug/m^3 (N=422), respectively (from EQUIS site reports). No further comment will be

made regarding Penticton since these, and the overall annual mean of 33 ug/m^3 (N = 276) from the current site (see Table 2), are well within air quality objectives.

Figure 3 shows the geometric mean TSP levels for some of the years for which a complete data set was available. Comparisons of the data collected in 1972 to 1979 and 1983 to 1989 show significant decreases (two-tailed t-test, P < .001) in TSP levels in both Lumby and Kelowna between these periods. While this obviously represents an improvement in air quality in Lumby, for the reasons outlined above, caution should be exercised in interpreting this as a similar change in the air quality in Kelowna.

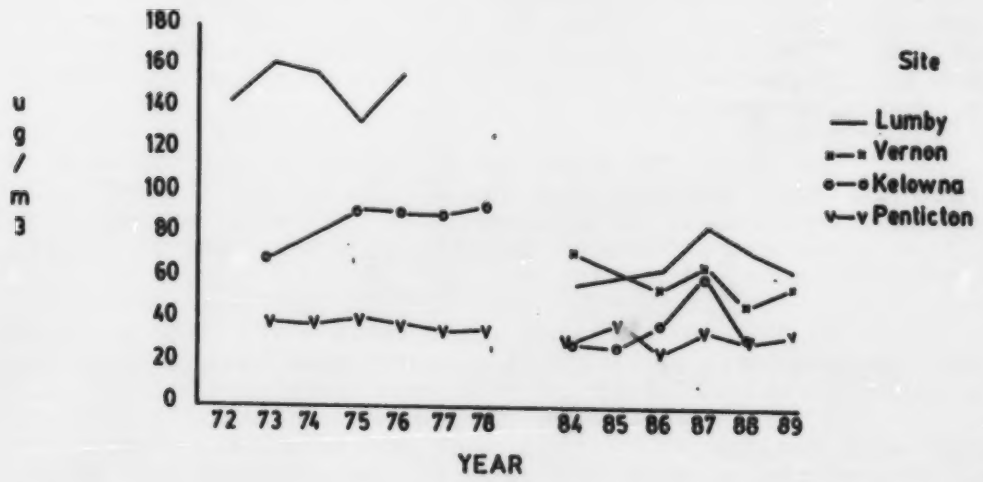


Figure 3. Annual geometric mean Total Suspended Particulate levels (ug/m^3) at Okanagan sampling sites. From 1972-1979 the sites were at Lumby Hotel, Kelowna Sunripe Plant, and Penticton Sewage Treatment Plant. From 1983-1989 they were at Lumby Home Furnishings Store, Vernon Geniers/RCMP, and Carmi School in Penticton.

There is also nothing to indicate that this improvement is the result of some linear process, therefore it would not be valid to assume that, since there has been an improvement from the 1970's to 1980's, this trend will necessarily continue in the future. It has been suggested (M.C.Coligado, pers comm) that even small displacements in sampler location, such as in Lumby, could

affect the sampling process. Several comments need be made regarding such potential inaccuracies in measuring air quality.

The apparently low levels of TSPs recorded in some communities (e.g. Penticton), may simply result from the fortuitous siting of the sampler, and that the majority of the community is subjected to higher TSP levels. However localised the high TSP (and dustfall) levels recorded at some sites, they do indicate that some indeterminate portion of the population are subject to a degraded atmospheric environment.

Given the expense of the sampling program, the siting of samplers must be critically determined. There also must be a long term commitment to operation of samplers. Or, when a sampler is relocated, a significant period in which sampling is carried out at both old and new sites. This would provide some continuity and a method of calibrating the new site against the old (as for Penticton Slumberlodge and Penticton STP).

2.3 DAILY TSP

The second expression of air quality used in both Provincial and Federal objectives is the total mass of suspended particulates per unit volume in a 24 hour sampling period (see Appendix A). The percentage of daily records at Lumby, Vernon, and Kelowna that exceeded the daily TSP objectives are shown in Figure 4a, b, and c, respectively.

The daily TSP measured in Penticton during each of 239 separate 24 hour periods was below the minimum level of both Federal and Provincial objectives. In Kelowna, of 284 records, four days were above Federal desirable level, and of these, one exceeded Provincial objective A.

In Vernon and Lumby the only data set in which no records exceeded air quality objectives was that from Vernon in 1983, although only 2 of 50 records were greater than 120 ug/m^3 in 1988. The 1983 data should be viewed with caution since only 18 records were available for this year and none from January to April, the months of high TSP levels. By contrast all 15 records for 1985 fell within this period, and of these 10 exceeded 120 ug/m^3. Even assuming the best case scenario (i.e. there was no other time in this year that the TSP levels exceeded 120 ug/m^3), and that a full data set consists of 50 variates, these 10 measurements would still show 20% of the records to be above Federally acceptable levels. In Vernon, TSP remained high through early 1991 (Appendix Figure 1).

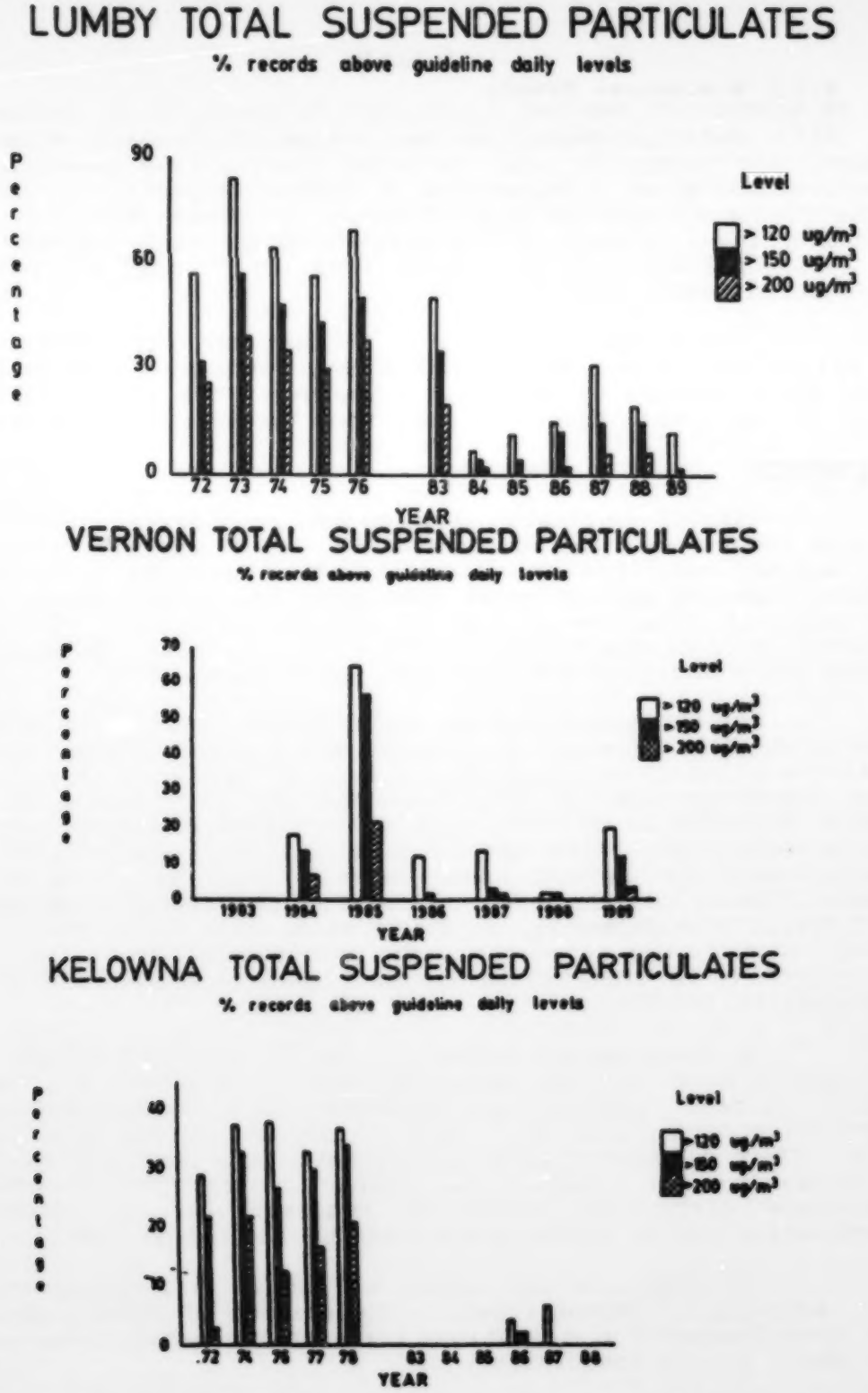


Figure 4. Percentage of 24-hour Suspended Particulate measurements made in (a) Lumby, (b) Vernon, and (c) Kelowna between 1973 and 1988, that exceeded federal acceptable, Provincial A, and Provincial B objectives

2.3.1 Historical Trends

For each year, the percentage of records at Lumby, Kelowna, and Penticton that exceeded the various governmental objectives are shown in Figures 4a, b, and c, respectively. A test of the frequency distribution of number of observations in each objective level showed a significant difference between the 1972-1979 and 1983-1989 data sets from both Lumby and Kelowna (Chi-squared tests, both $P < .001$).

The change in the number of Daily TSP measurements that fell within each objective level in Lumby, for the reasons outlined above, again appears to represent a change in the actual emission levels in the area. Again the data from Kelowna is equivocal.

2.4 COMMENTS

It is unlikely that climatic changes could have produced the dramatic and consistent drops in TSP levels evident in Lumby and Kelowna. Also, the sampling sites involved in Lumby are so close together that it seems improbable that such changes could have resulted from the change in sampler location. The same argument cannot be applied to Kelowna where, at least subjectively, the two sites involved are different in character.

Other possibilities that could have produced the observed drop in measured TSP levels are, either changes in the sampling equipment or actual reductions in TSP emissions in the areas. Sampler designs have been changed to maintain a more constant air flow as filters clog and increase resistance to the pumping mechanism. When and if such changes were made to the Okanagan samplers is not known but improved air flow should increase, rather than decrease, the mass of particulates trapped on the filters. Consequently, it would seem, that there has been a real decrease in the total suspended particulate levels in Lumby. The origin of the high TSP levels in Vernon is unclear, However, three possibilities exist:

a) they are the product of burner activity in the Lumby - Lavington area. There are many days when there is strong, visible (albeit subjective) evidence that smoke from the Lumby-Lavington burners does have an impact on air quality in Vernon. The confusing pattern of correlations between dustfall and TSP (Richardson and Adams, 1989) suggest a more complex model of particulate dispersion would be required for an objective determination of the inter-relatedness of the two parameters.

b) they are the result of industrial, transport, or other activity in Vernon itself. The absence of other samplers, or of size-frequency distributions for airborne particulates makes any comment purely speculative, or

c) they originate outside the Lumby/Vernon area. There are significant temporal relationships between most of the high volume sampler results (Table 3), suggesting an underlying, common factor in the production or dispersal of suspended particles in the area.

TABLE 3

Spearman coefficients of correlation between TSP levels at each of the Okanagan high volume sampler sites to 1988

	Vernon	Kelowna	Penticton
Lumby	0.214**	0.077	0.177*
Vernon		0.241**	0.273**
Kelowna			0.167

* significance level between 0.05 and 0.01
** significance level between 0.01 and 0.001

Reid (1988) also suggests a relationship between atmospheric conditions and suspended particulate levels, particularly the venting index. While these broad scale parameters seem the most likely to produce positive correlations between TSP levels at different sites, no relationship could be found between TSP at any of the sites and mean monthly temperature, rainfall, or total precipitation (Spearman Rank Correlations, $P > 0.05$ in all cases).

Reid (1988) found substantially elevated levels of both TSP and PM10 in Kelowna during the peak burning months in September and October 1987. During this period both impacted and non-impacted periods were sampled several times. The greatest impact occurred on days when visual impacts were most apparent. Background samples revealed little impact on very clear days. Analysis of long term SEAM and EQUIS data however (Figure 2), shows that TSP is not substantially elevated in the fall compared to other periods. This apparent contradiction is explained by differences in sampling methodology (Reid = event, SEAM/EQUIS = every 6 days). It is also important to remember that TSP is a broad measure of all suspended particulate. Comparison of data is difficult if the source of ambient particulate is unknown. For example wind blown soil can easily elevate TSP on an otherwise clear day to 80 ug/m^3. Smoke from a slash burn can totally obscure local visibility, and also show a TSP value of 80 ug/m^3. More precise particle size data are required to draw conclusions as to the source of impact.

3. DUSTFALL

Only selected sites will be discussed in this section of the report as the number of dustfall canisters is large, the corresponding data set enormous, and access to some data difficult. Four canisters in Summerland (E207262 and 263, and E207661 and 663), and four around the perimeter of Skaha Lake (E206759 to 762), are not considered here as they are either newly established or were operated for a specific purpose over a short period of time. Data from the canisters located with high volume samplers will be discussed in detail because their location is not directly related to the presence of permitted emission sources.

SEAM site reports contain data from varying periods between 1985 and early 1989 and with varying degrees of completeness. Since the sampling effort at each of the sites shows no monthly bias, it is unlikely that any non-random seasonal effects have been reflected in the overall data sets. EQUIS site data was used for temporal comparisons, but these data were collected during different periods at different sites, and sampling in many years was not complete. Consequently they provide only an approximate measure of the actual dustfall rate during the sampling period.

3.1 TOTAL DUSTFALL

The geometric means of dustfall rates measured at some of the Okanagan sites are shown in Table 4. It is evident that air quality differs greatly, not only from community to community, but from site to site within a much more limited range. For example, in Okanagan Falls there are two sites within one and a half kilometres of each other. Yet the mean dustfall rate for one (Lynn Acres 0500520) is 7.85 $mg/dm^2/d$ and for the other (Okanagan Falls control 0500826) was 0.47 $mg/dm^2/d$. This contrast between two adjacent sites means that caution should be exercised in making strong inferences about differences in air quality between any two sites.

Even though dustfall at the Vernon, Kelowna, and Penticton sites is low this is not unequivocal evidence that the air quality in these communities is better than in Lumby, Princeton or Okanagan Falls. The subjective view obtained from visits to each of the communities is that the data does represent the true state of affairs and obviously a greater proportion of these larger communities is beyond the dust deposition range of any emission sources within them.

TABLE 4

Geometric means and sample sizes of total particulate dustfall ($mg/dm^2/d$) in the Okanagan Region recorded in EQUIS (1973 - 1984) and in SEAM (1985 - 1989)

Site name	EQUIS data mean	N	SEAM data mean	N	
Lumby Weyerhaeuser	3.22	55	3.08	34	
Lumby Chas. Bloom School	1.15	55	1.10	34	
Lumby Home Furnishings	2.20	57	2.35	44	
Lumby Air South	3.44	127	3.00	40	
Lumby Ruesch Residence	4.56	69	3.81	40	
Lavington Air East	2.39	48	3.90	40	
Lavington Harbour	4.26	87	4.92	40	
Vernon Geniers/RCMP	0.66	13	0.72	47	
Kelowna Okanagan College		4	0.48	37	
Westbank Gorman Bros N		0	3.65	22	
Westbank Glen Rosa Rd		0	1.11	34	
Summerland Forest Prod N		0	14.30	25	
Summerland Forest Prod NNW		0	17.30	28	
Penticton STP	1.30	124	0.71	34	
Penticton Carmi School	0.22	4	0.43	45	
Okanagan Falls Lynn Acres		4.39	74	7.85	40
Okanagan Falls South		0.69	16	0.77	37
Okanagan Falls Control		0.35	16	0.47	38
Princeton Roccomatisi Res	3.37	48	4.62	37	
Princeton #13 Pines Ct	1.54	34	1.41	35	
Grand Forks Clark	1.50	110	1.44	38	
Grand Forks N Parta	7.86	87	5.86	36	
Grand Forks Makaoff	1.87	41	1.87	36	
Grand Forks Mayflower Hotel	1.77	41	1.40	37	
Grand Forks Como Rd		0	1.10	45	

The overall average of total dustfall from all sites within British Columbia (Anon 1989), for the period 1983 - 1987, is 1.62 $mg/dm^2/d$; that for the 25 Okanagan area sites considered in this report is 3.27 $mg/dm^2/d$. Even eliminating the two Summerland sites, which seem aberrantly high, the average is 2.43 $mg/dm^2/d$. Because these averages are a function of sampling effort around point emission sources, temporal and spatial comparisons cannot be made directly. But, the averages do strongly suggest comparatively high dustfall levels.

Table 5 shows the number of records from each site that exceed 1.75 $mg/dm^2/d$ and 2.90 $mg/dm^2/d$, which are the Provincial A and B objectives, respectively. It is a matter of some concern that for many of the samplers the majority of measurements exceed even the more lenient of these objectives.

TABLE 5

The number of total dustfall records for Okanagan dustfall canisters 1985-1988, and the number of those records that exceeded Provincial A and B air quality objectives of 1.75 mg/dm²/d and 2.90 mg/dm²/d, respectively

Site name	# of records	> 1.75 mg/dm²/d	> 2.90 mg/dm²/d
Lumby Weyerhaeuser	35	32	24
Lumby Chas. Bloom School	34	7	0
Lumby Home Furnishings	44	40	12
Lumby Air South	40	34	25
Lumby Ruesch Residence	40	33	32
Lavington Air East	40	33	21
Lavington Harbour	40	39	34
Vernon Geniers/RCMP	45	1	0
Kelowna Okanagan College	37	0	0
Westbank Gorman Bros N	22	21	17
Westbank Glen Rosa Rd	20	2	0
Summerland Forest Prod N	25	25	25
Summerland Forest Prod NNW	28	28	28
Penticton STP	34	4	1
Penticton Carmi School	45	0	0
Okanagan Falls Lynn Acres	40	39	39
Okanagan Falls South	37	7	5
Okanagan Falls Control	38	4	0
Princeton Roccomatisi Res	37	34	31
Princeton #13 Pines Ct	35	12	5
Grand Forks Clark	38	20	12
Grand Forks N Parta	36	36	35
Grand Forks Makaoff	36	19	6
Grand Forks Mayflower Hotel	37	8	0
Grand Forks Como Rd	45	13	3

Of the 908 records analyzed here, the percentage exceeding Provincial A and B air quality objectives was 54.1% and 39.1%, respectively.

3.1.1 Historical Trends

A comparison of the data from EQUIS and SEAM shows no general decrease in either total dustfall (Table 4) or the percentage of days exceeding air quality objectives (Tables 6 & 7). Of the 19 sites for which there was the necessary data, nine showed an increase, and nine a decrease, in total dustfall.

Because access to the EQUIS raw data is difficult, statistical comparisons of the data for the two time periods at all sites was not possible. Comparisons of the distribution of observations within each of the objective levels showed the differences between time periods could be accounted for on the basis of chance in the sampling process (Chi-square tests, $p < 0.05$ in all cases). Note that not all sites could be compared in this way due to the limitation of Chi-square tests that expected values

should not be less than 5 in more than 20% of the cells (Sokal and Rohlf 1969).

The 54.1% of SEAM records that exceed Provincial A objectives, and the 39.1% exceeding Provincial B objectives is consistent with data given by Leung and Manna (1986) for the years 1976 to 1982. However, the number and location of samplers in 1976 - 1982 was different even between years and consequently these data do not provide an accurate assessment of changes in dustfall.

TABLE 6

A comparison of the percentage of records in EQUIS (1973-1984) and SEAM (1985 - 1989) that exceeded Provincial A air quality objective of 1.75 mg/dm^2/d

Site	EQUIS data %	EQUIS data N	SEAM data %	SEAM data N
Lumby Weyerhaeuser	90.9	55	91.5	35
Lumby Chas. Bloom School	14.5	55	20.6	34
Lumby Home Furnishings	84.2	57	90.9	44
Lumby Air South	89.0	127	85.0	40
Lumby Ruesch Residence	95.5	67	82.5	40
Lavington Air East	83.3	48	82.5	40
Lavington Harbour	93.1	87	97.5	40
Vernon Geniers/RCMP	0.0	13	2.1	47
Kelowna Okanagan College	0.0	4	0.0	37
Westbank Gorman Bros N		0	95.5	22
Westbank Glen Rosa Rd		0	10.0	20
Summerland Forest Prod N		0	100.0	25
Summerland Forest Prod NNW		0	100.0	28
Penticton STP		0	17.8	34
Penticton Carmi School	0.0	4	0.0	45
Okanagan Falls Lynn Acres	93.2	74	97.5	40
Okanagan Falls South	0.0	16	17.9	37
Okanagan Falls Control	0.0	16	10.5	38
Princeton Roccomatisi Res	95.8	48	91.9	37
Princeton #13 Pines Ct	41.1	34	34.3	35
Grand Forks Clark	35.5	110	52.7	38
Grand Forks N Parta	87.4	87	100.0	36
Grand Forks Makaoff	65.9	41	52.8	36
Grand Forks Mayflower Hotel	40.9	44	21.6	37
Grand Forks Como Rd		0	28.9	45

Unlike the dramatic changes in TSP levels in Lumby, there are no indications that there was any comparable change in dustfall; there are no trends in Lumby or any other area where dustfall was monitored. In Vernon, dustfall remained unchanged through early 1991 (Appendix Figure 2).

TABLE 7

A comparison of the percentage of records in EQUIS (1973-1984) and SEAM (1985 - 1989) that exceeded the Provincial B air quality objective of 2.90 mg/dm²/d -

Site	EQUIS data %	EQUIS data N	SEAM data %	SEAM data N
Lumby Weyerhaeuser	63.4	55	68.6	35
Lumby Chas. Bloom School	3.6	55	20.6	34
Lumby Home Furnishings	29.8	57	27.3	44
Lumby Air South	68.8	127	62.5	40
Lumby Ruesch Residence	82.1	67	80.0	40
Lavington Air East	43.8	48	52.5	40
Lavington Harber	70.1	7	85.0	40
Vernon Geniers/RCMP	0.0	13	0.0	47
Kelowna Okanagan College	0.0	4	0.0	37
Westbank Gorman Bros N		0	77.3	22
Westbank Glen Rosa Rd		0	0.0	20
Summerland Forest Prod N		0	100.0	25
Summerland Forest Prod NNW		0	100.0	28
Penticton STP		0	2.9	34
Penticton Carmi School	0.0	4	0.0	45
Okanagan Falls Lynn Acres	62.5	48	97.5	40
Okanagan Falls South	17.6	16	13.5	37
Okanagan Falls Control	0.0	16	10.5	38
Princeton Roccomatisi Res	63.0	48	83.8	37
Princeton #13 Pines Ct	18.0	34	14.3	35
Grand Forks Clark	23.6	110	31.6	38
Grand Forks N Parta	83.9	87	97.2	36
Grand Forks Makaoff	2.4	41	16.7	36
Grand Forks Mayflower Hotel	9.8	41	0.0	37
Grand Forks Como Rd		0	6.7	45

3.1.2 Comments

The impact of sawmill activity on total dustfall deposition is demonstrated by the fluctuations in dustfall measured through 1985 - 1986. In Lumby there was a drop in dustfall in August, September, November, and December of 1986 (Figure 5). This coincides with a mill shutdown from July 22 to December 10, 1986. A similar drop was evident in the data from Princeton where the samplers are located close to another Weyerhaeuser mill. Unfortunately there were no dustfall measurements during that period at the Okanagan Falls Lynn Acres (0500520) site, close to a third Weyerhaeuser mill in the Region. A simultaneous peak in dustfall was observed at Lavington Harber (0500439), close to the Lavington Planer Mill which did operate then (July - December 1986).

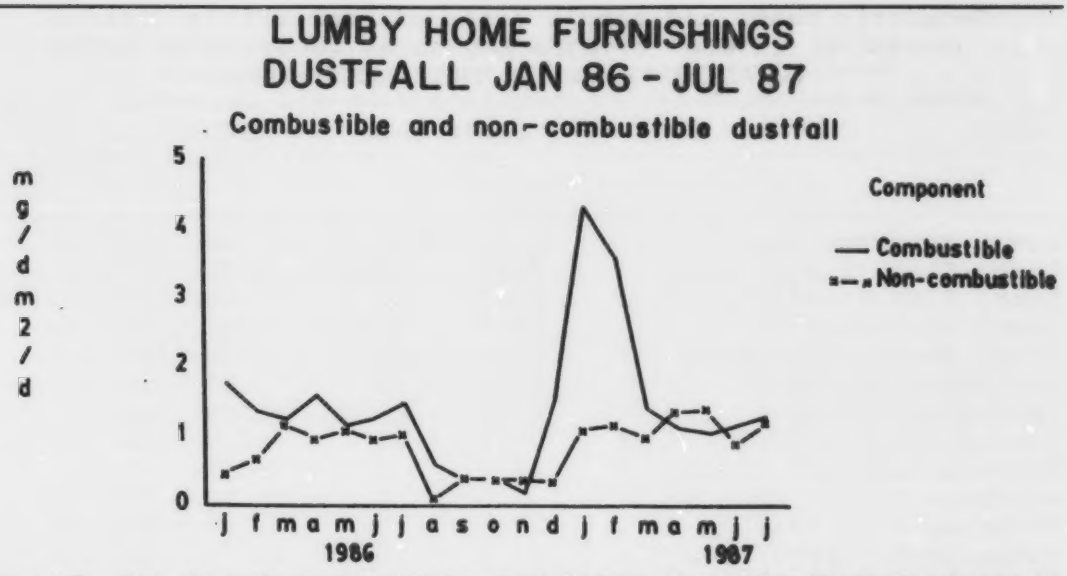


Figure 5. Total and combustible dustfalls at Lumby Weyerhaeuser in the months before, during, and after closure by industrial dispute of the Weyerhaeuser mill from 86.07.22 to 86.12.10.

A temporal comparison of TSP and dustfall at Lumby Home Furnishings failed to show any correlation between the two variables (Richardson, Adams, and Bryan 1991). The simultaneous decrease in TSP and constancy of dustfall levels suggests that these two pollutants are generated by different sources, or at least subject to different control methods. Unfortunately, as a compounding factor in interpreting this data, dustfall at some of the other Lumby sites was correlated with TSPs measured at Lumby Home Furnishings, while the Lavington East dustfall was negatively correlated with TSP at Lumby.

3.2 COMBUSTIBLE DUSTFALL

Both the combustible dustfall level and the relative levels between the EQUIS and SEAM sampling periods follow a similar pattern to that observed for total dustfall (Table 8). At seven of the sites the combustible dustfall alone exceeds the Provincial A objective of 1.75 $mg/dm^2/d$. Thirteen of the sites showed an increase in combustible dustfall between the EQUIS and SEAM periods, while six showed a decrease. Only the increases at Okanagan Falls Lynn Acres and Princeton Roccamatisis Residence were statistically significant ($P < 0.05$, one tailed t-tests).

In contrast to the limited evidence from the TSP measurements that indicate an improvement in air quality, the dustfall data suggests that air quality in the proximity of some of the major dustfall emitters is unchanged during the periods for which data is available.

TABLE 8

Geometric means and sample sizes of combustible dustfall ($mg/dm^2/d$) in the Okanagan Region as recorded in EQUIS (1973-1984) and in SEAM (1985-1989)

Site	EQUIS data mean	N	SEAM data mean	N
Lumby Weyerhaeuser	1.74	51	1.68	34
Lumby Chas. Bloom School	0.62	25	0.72	34
Lumby Home Furnishings	0.83	53	1.42	44
Lumby Air South	1.79	58	1.66	40
Lumby Ruesch Residence	2.35	69	2.30	40
Lavington Air East	1.22	45	1.28	40
Lavington Harber	2.20	55	1.68	40
Vernon Geniers/RCMP	0.25	13	0.30	45
Kelowna Okanagan College		4	0.30	37
Westbank Gorman Bros N		0	0.59	34
Westbank Glen Rosa Rd		0	2.63	22
Summerland Forest Prod N		0	13.74	25
Summerland Forest Prod NNW		0	17.10	28
Penticton STP	0.69	50	0.41	31
Penticton Carmi School	0.14	4	0.25	45
Okanagan Falls Lynn Acres	1.35	45	2.31	40
Okanagan Falls South	0.40	58	0.56	37
Okanagan Falls Control	0.25	16	0.28	38
Princeton Roccomatisi Res	1.81	48	2.82	37
Princeton #13 Pines Ct	0.76	33	0.93	35
Grand Forks Clark	0.39	23	0.47	38
Grand Forks N Parta	4.19	41	5.05	36
Grand Forks Makaoff	1.26	41	1.48	36
Grand Forks Mayflower Hotel	0.97	40	0.92	37
Grand Forks Como Rd		0	0.41	45

Significant non-combustible dustfall rates are also noted to occur near sawmill sites (see Table 9). For example, at Okanagan Falls Lynn Acres combustible dust forms the lowest percentage of total dustfall. Both samplers located close to the burner at Lavington Planer Mill showed combustible dustfall was less than 50% of the total dustfall. By comparison, at several sites with low total dustfall (2 Penticton sites, Kelowna, Okanagan Falls Control) over 70% of the dustfall was combustible. There were also surprisingly strong relationships between combustible and non-combustible dustfall at some sites (Table 9). This relationship seems independent of the total dustfall.

TABLE 9

Combustible dustfall as a percentage of total dustfall and spearman coefficient of correlation between combustible and non-combustible dustfall recorded at each Okanagan site in the period 1983 - 1989.

Site	Total dust	% combustible	Correlation
Summerland Forest Prod NNW	17.30	91.7	0.42 **
Summerland Forest Prod N	14.30	87.6	-0.22
Okanagan Falls Lynn Acres	7.85	33.6	0.21
Grand Forks N Parta	5.86	87.2	0.15
Lavington Harber	4.92	46.2	0.13
Princeton Roccamatisi Res	4.62	65.8	0.42 **
Lavington Air East	3.90	42.9	0.57 ***
Lumby Ruesch Residence	3.81	62.8	0.46 ***
Westbank Gorman Bros N	3.65	75.2	0.54 **
Lumby Weyerhaeuser	3.08	57.5	0.47 ***
Lumby Air South	3.00	59.3	0.32 *
Lumby Home Furnishings	2.35	61.9	0.19
Grand Forks Makaoff	1.87	81.3	0.14
Grand Forks Clark	1.44	48.9	0.49 **
Princeton #13 Pines Ct	1.41	67.8	0.58 ***
Grand Forks Mayflower Hotel	1.40	66.9	0.42 **
Westbank Glen Rosa Rd	1.11	75.0	-0.04
Lumby Chas. Bloom School	1.10	62.8	0.50 ***
Grand Forks Como Rd	1.10	46.1	0.28
Okanagan Falls South	0.77	81.5	0.52 ***
Vernon Genier's/RCMP	0.72	48.5	0.12
Penticton STP	0.71	70.1	0.08
Kelowna Okanagan College	0.48	71.8	-0.10
Okanagan Falls Control	0.47	77.4	-0.09
Penticton Carmi School	0.43	73.7	-0.29

* $P < 0.1$
** $P < 0.05$
*** $P < 0.01$

3.2.1 Comments

Dustfall at each site is obviously subject to a unique set of conditions. The high proportion of non-combustible dust at Grand Forks Clark, located close to the Pacific Abrasives plant, is probably reflective of the inorganic materials used in that plant. At the Lavington sites, a number of complaints indicate that the source of the large non-combustible dustfall is vehicle activity in an unpaved sort yard. The high combustible dustfall component at the Summerland Forest Products mill is mainly fugitive wood chips and saw-dust from storage and loading facilities. A similar problem exists at Grand Forks Parta Industries, producing high proportions of combustible dustfall at both the Parta and nearby Makaoff Residence samplers.

4. OZONE

Ozone levels were measured in Penticton (Carmi 0500869) as part of the NAPS program from September 1983 until May 1987. A more continuous record of ozone levels has been recorded at the Okanagan College site in Kelowna (0500886) from August 1983 to 1988. The Okanagan College site became the NAPS site for the Okanagan in June of 1987.

Ozone is created naturally in a photochemical reaction of sunlight acting on volatile organic carbon and oxides of nitrogen. Unlike most other air contaminants, ozone is present at significant (20 - 30 ppb) background levels. Areas such as the Okanagan that experience an abundance of sunshine may also have higher than normal background ozone levels. The extent to which anthropogenic sources contribute to the ozone load in the Okanagan is not known. Ozone is generated from automobile exhaust. As the number of cars and trucks increase, ozone levels will also increase, although improved emission control will offset the increased number of engines.

Air quality objectives for ozone levels in British Columbia are expressed in hourly and yearly terms (Appendix A). The level deemed desirable over a one year averaging period is 30 ug/m^3. The maximum desirable level for a single 1-hour sample is 100 ug/m^3. Table 10 contains the number of records exceeding the 1-hour level A objective of 100 ug/m^3 on a monthly basis for years 1985 to 1989. The percentage of excessive levels increases significantly during the months of April, May, June and July.

Indeed, 16% of the hourly values exceeded the Federal objective in May 1987. Figure 6 shows the monthly mean ozone levels for years 1985 to 1988. Figure 6 shows a consistent increase in ozone during the spring and summer months as solar radiation increases. Average annual ozone at Kelowna has no trend for the period of record. Average levels of 41.3, 35.1, 42.4, 41.5 and 33.5 ug/m^3 were recorded for years 1985 to 1989 respectively.

TABLE 10

Percentage of ozone records exceeding the 1-hour level A objective of 100 ug/m³ at Okanagan College, Kelowna for years, 1985 - 1988.

Month	Years							
	1985		1986		1987		1988	
	%	(N[1])	%	(N)	%	(N)	%	(N)
Jan	0	631	0	545	0	36	0	686
Feb	0	497			0	640	0	652
Mar	0	743	0	722	0.1	708	0	601
Apr	0.5	375			7.5	683	1.3	615
May	5.4	722	1.2	724	16.2	703	4.1	708
June	7.6	701	0.9	447	9.0	676	4.7	685
July					7.2	671	4.2	710
Aug	2.8	531	0	81	1.0	603	4.1	603
Sept	0	671	0	688	1.1	662	1.6	573
Oct	0	600	0	484	0	523	0	593
Nov	2.6	701	0	400	0	606	0	498
Dec	0	673	0	135	0	709	0	702

1. (N) = number of hourly records for month.

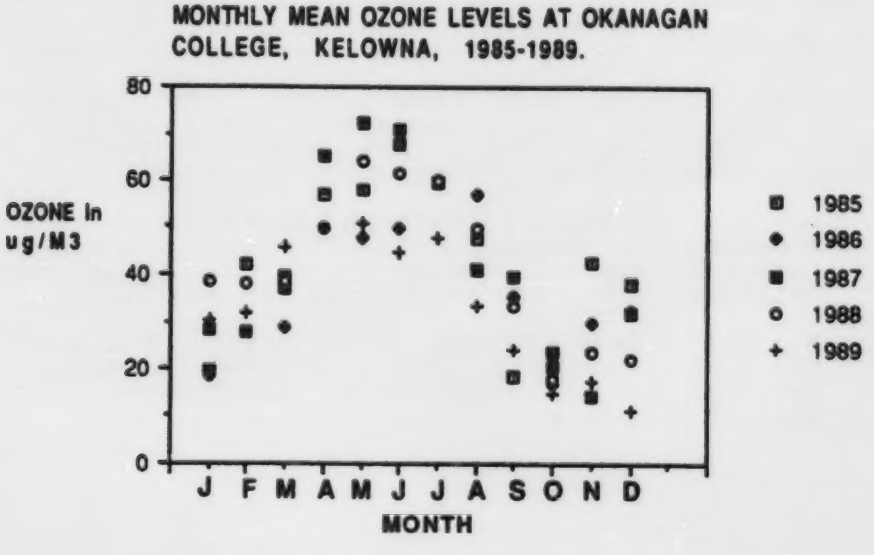


Figure 6. Monthly mean ozone levels at Kelowna, Okanagan College, 1985-1988.

5. REFERENCES

Anderson, D.O., 1967. Effects of Air Contamination on Health. Background Paper A3-3 in Pollution and Our Environment. Canadian Council of Resource Ministers, Montreal, Canada

Anon. 1977. Pollution Control Objectives for the Forest Products Industry of British Columbia. Ministry of Environment, Victoria, British Columbia.

Anon. 1979. Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia. Ministry of Environment, Victoria, British Columbia

Anon. 1983. Ambient Air Quality Criteria for Particulates. Air Quality Standards Committee, Ministry of Environment, Victoria, British Columbia

Anon. 1989. Air Quality Trends in British Columbia 1983 - 1987. Draft Report, Ministry of Environment, Victoria, British Columbia

Bhattacharya, K.K., 1988. Woodwaste Incineration and Air Quality in Williams Lake. Internal Report, Ministry of Environment and Parks, Victoria, British Columbia

Crozier, R., and B. Manna.1988. Impact of Residential Wood Combustion on Ambient Air Quality in Cranbrook, B.C., Canada. Proceedings PNIWS 25th Annual Meeting, Whistler, British Columbia, Nov 9-11, 1988, pp2D:1-12

Good, D.P., and R.L. Doering. 1980. Annual Compendium of Environmental Law in Canada. Good. Ottawa, Canada

Katz, M. 1967. Nature ad Sources of Air Pollution. Background Paper A2-2 in Pollution and Our Environment. Canadian Council of Resource Ministers, Montreal, Canada

Leung, T.B. and B.B. Manna. 1986. Air Quality Trends in British Columbia 1976 - 1982. Appendix H. Air Quality Trends in Okanagan Region 1976 - 1982. Ministry of Environment, Victoria, British Columbia

Reid, P.D. 1988. Air Quality Impacts from Slash Burning and Sawmill Woodwaste Burning Activities in the Interior of British Columbia. Proceedings of PNWIS 25th Annual Meeting, Whistler, B.C., Nov 9-11, 1988, pp 4D3-13

Richardson, H., S.R. Adams and J.E. Bryan, 1991. Air Quality in the Lumby- Lavington Area of British Columbia. Draft Internal Report, Ministry of Environment, Victoria, British Columbia

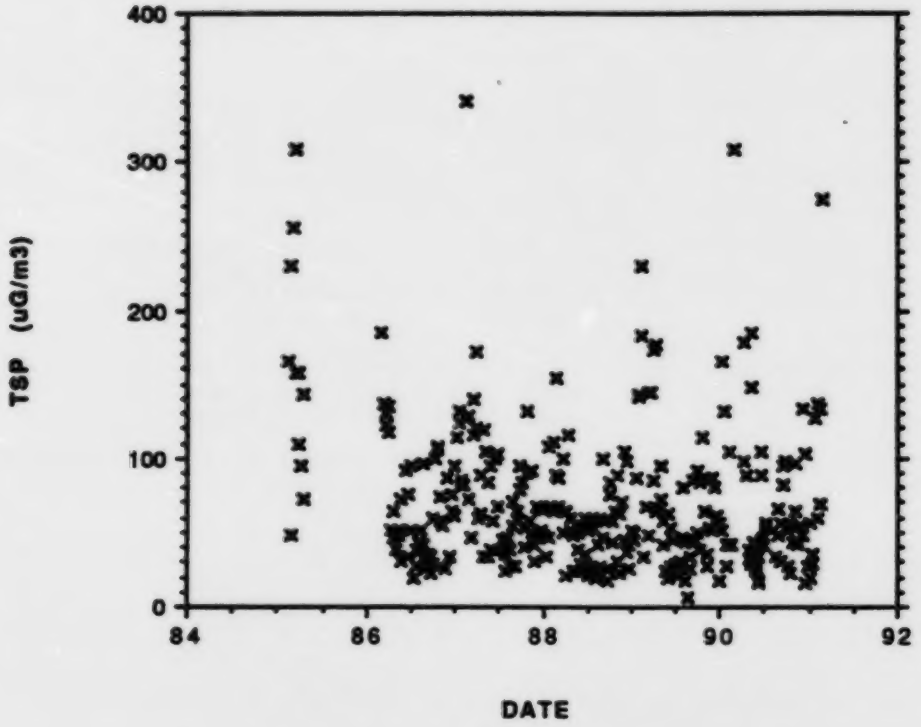
6. APPENDIX

GOVERNMENT AIR QUALITY OBJECTIVES

Parameter	Analysis	Range period	Objective Level*
Total suspended particulates (ug/m^3)	24 hours	< 120	Federal acceptable
		120-400	Federal tolerable
		< 150	Provincial A
		150-200	Provincial B
		> 200	Provincial C
	1 year (geometric mean)	< 60	Federal desirable & Provincial A
		60-70	Provincial B
		70-75	Provincial C
Total dustfall ($mg/dm^2/d$)	1 month	<1.75	Provincial A (residential)
		<2.90	Provincial B
Ozone (ug/m^3)	1 hour	100	Federal Max. Desirable and Provincial Level A
		160	Federal Max. Acceptable and Provincial Level B
		300	Provincial Level C
	1 year (arithmetric mean)	30	Federal Desirable Level Provincial Level B

* All levels specify the maximum contaminant for each of the three Levels: A,B,C. Level A is the desirable objective intended to provide long term protection. Level B is the acceptable objective which will provide adequate protection from adverse effects on health of plants, animals, and humans. Level C is the tolerable objective which denotes the level of air contaminant that requires appropriate action to prevent exceedances, because greater levels imply a diminishing margin of safety for health of plants, animals, or humans.

Appendix Figure 1. TSP in Vernon.



Appendix Figure 2. Dustfall in Vernon.